Accelerators Controls Experience

1. Background - Cooperation with DESY-FLASH/XFEL and ESS
    1.1. Controls @FLASH/XFEL and DMCS participation
    1.2. Controls @ESS and DMCS participation
2. Best practice in design and implementation?
3. Lesson learned with respect to controls ?
4. Controls migration experience ?
5. What requirements did you get/not get (and should have) for previous controls projects?
6. What languages and frameworks have you used for writing user applications?
7. git repository structure: what products have you used; what are their differences?
8. experience with uTCA

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on behalf of LUT- DMCS team

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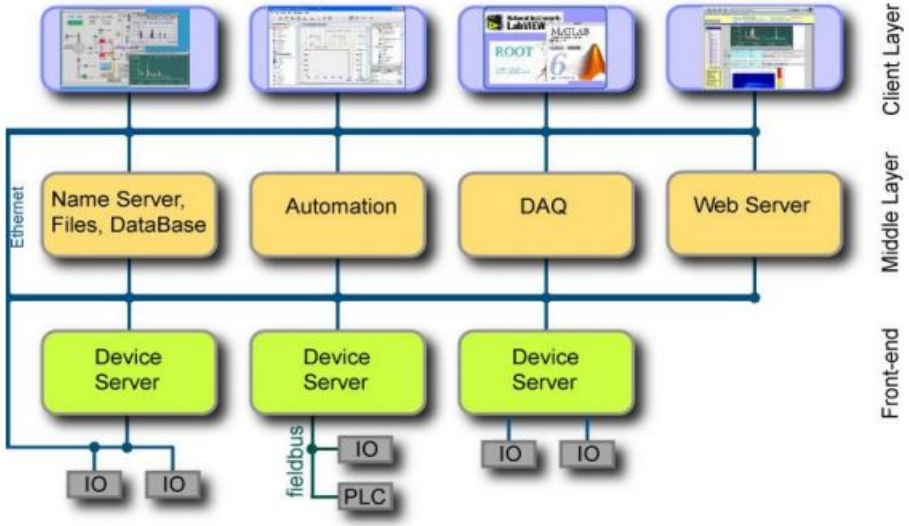
DESY controls and DMCS

- **DESY** is using different hardware platforms for various applications,
- **RF/LLRF systems** mainly based nowadays on MTCA.4 standard,
- DESY initiated (together partners) MTCA.4 efforts and is involved in standard development and popularization,
- successful migrations between different technologies **VME (DSP)** -> **VME (FPGA - Simcon)** ->(ATCA)->**MTCA.4** (current implementation),

- for software: **DOOCS** is used as a leading CS framework (but also TINE and EPICS are used in dfferent subsystems)



source: doocs.desy.de

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DESY controls and DMCS

- **DMCS** have been involved in LLRF system HW dev. since early 2000,
- Co-design **FPGA based HW** platforms for controller realization,
- co-design **VME** form-factor and **ATCA** (transition state) then **MTCA.4** modules (together **with ISE-WUT**)
- participated in **FW/SW development** from controller algorithm implementation, **device drivers** and **user applications** preparation up to the GUI design.

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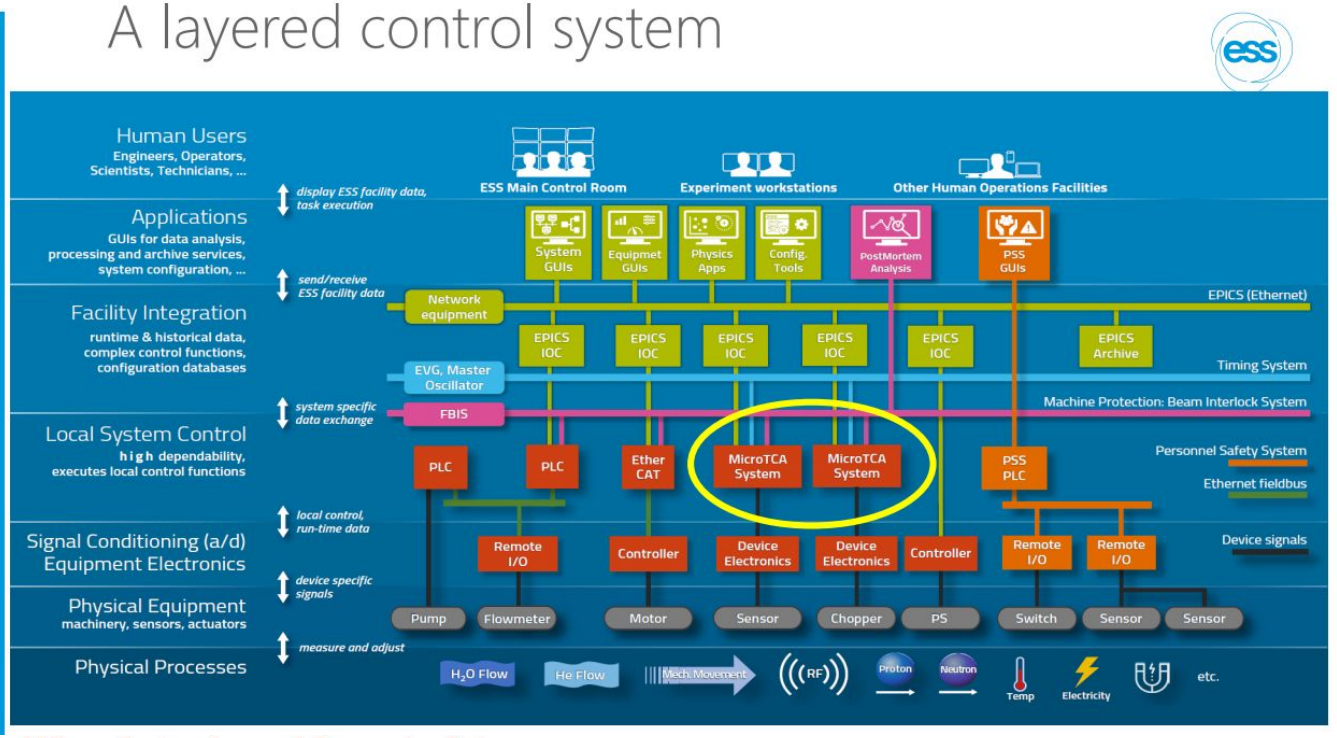
ESS controls and DMCS

- ESS has chosen **MTCA.4** architecture as a **leading hardware** platform for:
  - RF/LLRF,
  - Beam instrumentation,
  - timing,
  - others.
- Base for **control system** - **EPICS**,
- dedicated **ESS EPICS Environment (E3)** framework for IOC management documentation and deployment.



source: H. Carling ICS-ESS

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ESS controls and DMCS

- **DMCS** involved in LLRF system co-design, integration, testing and delivery as a part of **PEG** (Polish Electronic Group) together with WUT and NCBJ,
- **PEG** delivers Polish in-kind to ESS project,
- **DMCS** designed and delivering **MTCA.4** module for piezo driver operation for spoke and elliptical cavities,
- Implements protection **algorithms** for **icBLMa** and **nBLM** systems (for nBLM: firmware, for icBLM: firmware, EPICS IOC, Phoebus GUIs)
- Integrates RTMCarrier AMC module (by NCBJ) used for piezo driver and LocalOscillator (WUT) management and operation - functional FW, system driver, IOC module and GUIs included,
- provides integration of the IPMI functionality in E3 environment (using openIPMI library,
- others

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Best practice in design and implementation

- code and hardware review should be controlled by project masters (code review),
- use known firmware framework and use off-the-shelf/vendor provided modules, libraries and IPs,
- integrate CI wherever you can,
- keep design and implementation core team consistent - to many rotations can lead to “vision” changes and constant systems requirements changes,
- plan ahead required functionality placement (firmware - HW level, middle layer - still RT or fast, user application slow control). This will allow to plan better for HW design,
- always leave HW resources overhead for functionality improvements,
- hardware You use for design is already “old” for operation phase.

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Controls migration experience

- Usage of standard frameworks (such as AXI on FW level) makes it easy to migrate,
- Migration between FPGA families from one vendor is easy
- Migration to the systems with the same type of interface (PCIe, ETH) easy.

Since we were not using well known FW framework or frameworks had one project life time, it was not easy in our case - even if systems are using the common hardware.
In most cases architecture of FW is independent (even for different projects within same institute).

Example: DESY LLRF -> ESS LLRF -> ESS BLMs.
Almost same HW 3 different FW frameworks

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What languages and frameworks have you used for writing user applications

Languages:

- VHDL (FPGA Level)
- Verilog (FPGA Level)

- C (embedded and control system)
- C++ (control system and FPGA Level - HLS, drivers, user applications),

- Python (UA prototyping)
- Matlab/SciLab/Octave (not a language - user application prototyping and evaluation)

Frameworks (we rather used custom solutions):

- e3 (Epics at ESS)
- AXI based FW framework

Many other tools and libraries…..

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What requirements did you get/not get (and should have) for previous controls projects

- various experience concerning requirements definition and review,
- “no initial specification” approach possible for system design/implementation - but lengthy (and costly),
- functional (and some non-functional) requirements management and reviews are essential for successful system implementation and integration - especially in case of in-kind collaboration work model,
- some non-functional requirements can be specified early and save extensive integration costs later,
  like eq. general:
  - compliance with given ISO or ANSI standards,
  - CE marking,

  or project specific:
  - deployment strategy/policy,
  - naming conventions,
  - FW/SW/GUI development guidelines/standards,
  - etc

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git repository structure: what products have you used; what are their differences

GIT

- independent projects for functional parts
- shared libraries moved to separate repos and included as submodules
- Makefile flow

Tools (GIT “frontends”, which simplify collaboration)

- GitLab (see picture on next slide)
  - user friendly interface - please upload your profile picture ;)
  - “I like this commit !  “
  - Comments to the code, but general code review seems not to be clear
- Gerrit (see picture on next slide)
  - developed by Google for internal purpose
  - raw techie interface
  - code review mechanics

ESS is also using cloud hosting for open source projects on GitHub (GitLab-like system) and BitBucket (Atlassian product)

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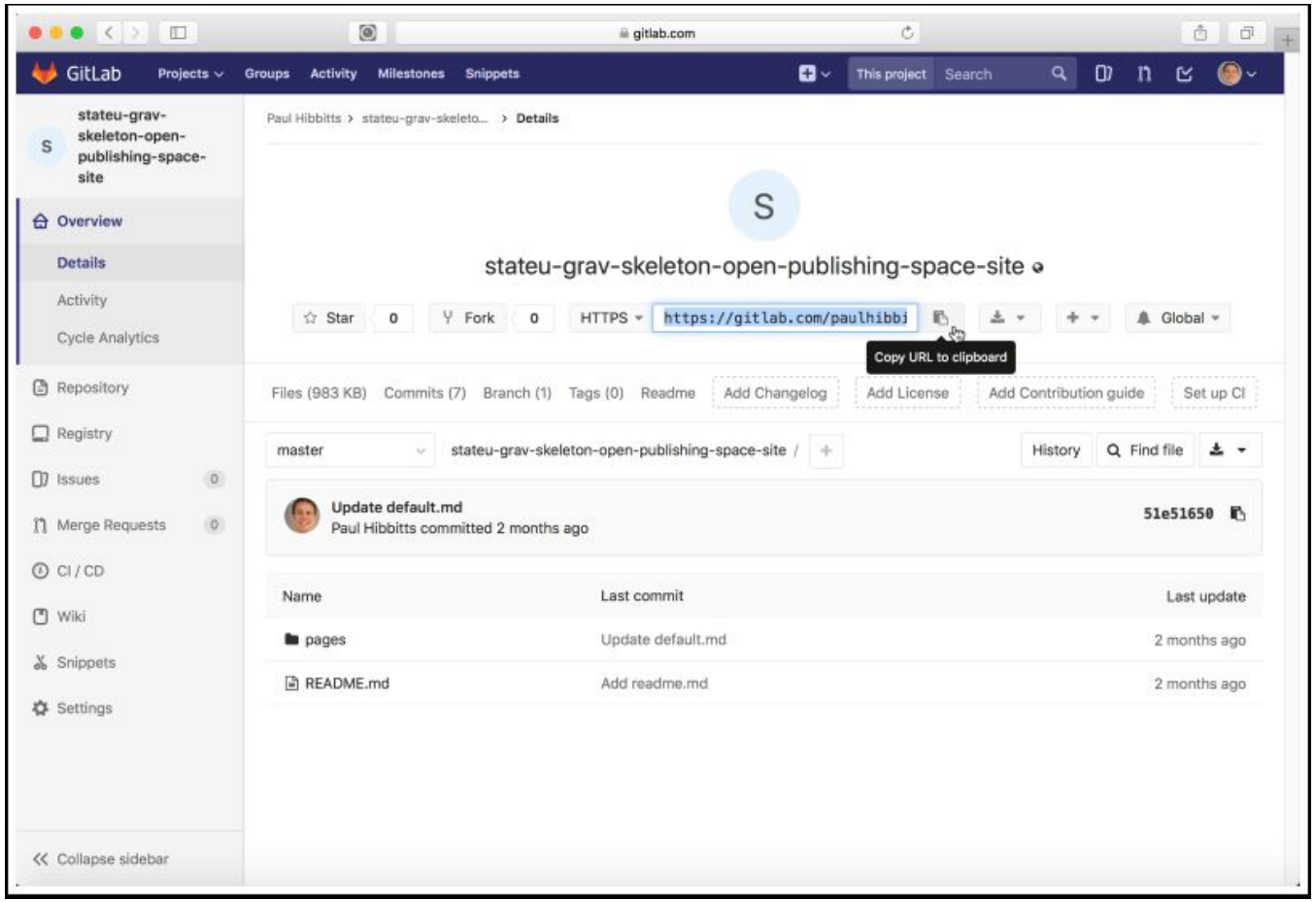

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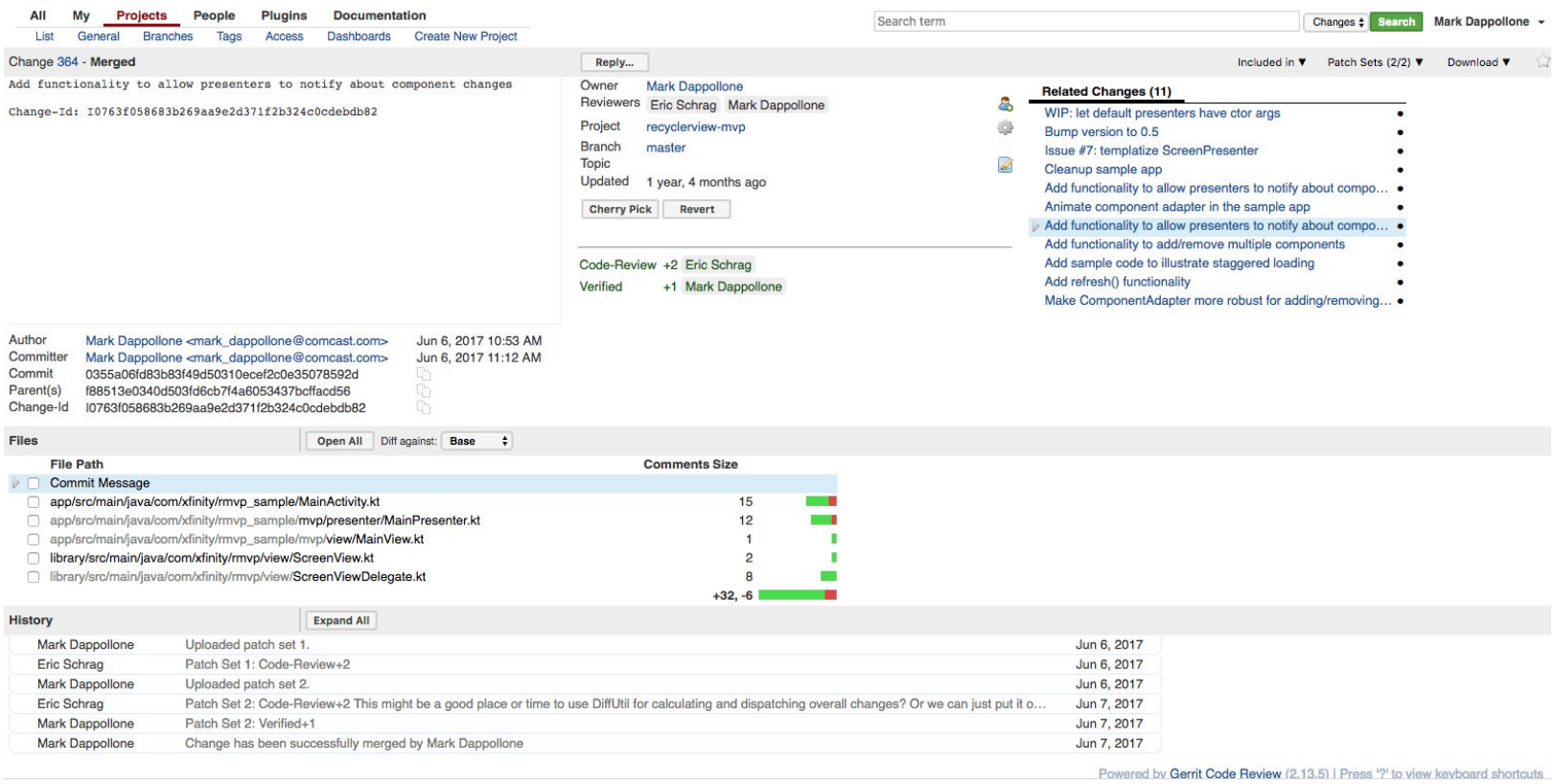

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Experience with uTCA

- Places: DESY, ESS
- Around 10 years experience with MTCA standards,
- Experience in the AMC, RTM modules design and production for LLRF and other systems,
- Experience in the FW as well as driver and software (DOOCS/EPICS) development, implementation and deployment,
- Pros:
  - growing standard originating from the telecom industry (ATCA) - promising lifetime,
  - fast growing vendors community that can provide COTS solutions for majority of implementation,
  - by definition integrates technologies like Ethernet, PCIe, IPMI and others for fast data transfer inside the crate and intelligent system management.
- Cons:
  - interoperability between different vendors components not always straightforward,
  - entry cost for small installations may be an issue,
  - specialized state-of-the-art solutions may need to be designed in-house (but then can be licensed and commercialized),
  - PCIe problems under investigation.

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Thank You

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